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DEPARTMENT OF NATURAL RESOURCES
AND ENERGY
NEW BRUNSWICK

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PROCESS STUDIES GROUP

QUARTERLY PROGRESS REPORT:

"COMMERCIAL DEVELOPMENT CONCEPTS"

by

J. Dean Thibault

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"Commercial Development Concepts"

MINERAL DEVELOPMENT

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The objective of interim reports is to provide project status on mineral processing studies being administered by Mineral Development and to assure a coordination of development among industry, government, universities, research and development.

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*NOTE: MPIP and MISP are funded by the Federal Government under the Mineral Development Agreement.

**PART TIME ASSISTANCE

It has been the mandate of the Provincial Government to develop the mineral wealth of the Province to its fullest. The predominant stage of development in the mineral industry of New Brunswick has been associated with "seed development" (better known as the primary development, required to commercialize a known mineral occurrence). In dealing with measures to strengthen seed development, one is concerned with resource identification (a delineation of resource tonnage and grade where a commercialized tonnage is to be defined, based on a market tonnage and economic life of the mine), marketing (identifying the most probable marketplace for mineral concentrates and/or possible chemical derivatives of a mineral), and processing methods (best suited technology to produce a marketable product base on the resource characteristics).

The overall goal of the Process Studies Group is to evaluate the technical and economic aspects of emerging and existing commercialized processing technologies, to liase with industry, and to recommend to the Province various ways in which research and development can be of assistance to the mineral industry of New Brunswick. In order to evaluate processing options for the development of Provincial resources, various studies have been carried out to characterize mineral extraction (determining the physical and chemical separation properties of the ore in addition to the chemical and mineralogical makeup of the ore) and to

identify the various market avenues and specifications. By establishing upgrading properties of the ore and/or concentrate, a preliminary flowsheet is designed to produce products based on the specifications of the market. The data from bench-scale flowsheet testing is used to preliminary design (scale-up) a commercial plant for capital and operating cost analysis (process economics). In addition to the economic feasibility of a development concept, the limitations to process selection are documented. Thus, processing development options for a resource are determined using an integrated approach. As a result of these incubation studies, information has been provided to investors on possible business opportunities and the need for large-scale research and development has been identified.

The administration of development programs, such as the Mineral Investment Stimulation Program (MISP) and the Mineral Processing Investigations Program (MPIP), has provided an insight into the limitations to commercialized development objectives relating to the competitiveness and diversification of New Brunswick's mineral industry. Productivity improvements have been noted as a predominant method to remain competitive, where the MISP has provided financial assistance to companies actively pursuing improvement studies. Identifying technological constraints to mineral processing and areas for diversification of the mineral industry has been the basic objective of the MPIP, where technical assistance has been provided to facilitate adjustment to a changing industry. In reviewing the growth of mineral

resource commercial development within New Brunswick, the following concepts have been recognized as areas that will help contribute to the future economic growth of mining and manufacturing.

Resource Identification

A fair number of mineral occurrences have been identified in New Brunswick, where the development potential of these occurrences has not been fully investigated. In some cases, resource definition is limited, with respect to grade and tonnage, making mining and process development premature. In order to establish any commercial development on a mineral occurrence, development geology has to be established in order to evaluate the mine making potential.

In addition to technical knowledge to delineate a resource, the ability to raise money for drill programs requires good business sense and "development enthusiasm" in the mining industry. The major investment risks in the mining industry are associated with drilling programs which can be very costly. This element of risk has been a major limitation to small resource companies. To date, funding for this type of development is limited as Government grant systems, where flow through monies have benefited the growth of independence within small companies' activities.

Market Potential

The growth of market trends and commodity prices tend to dictate areas for exploration and development. Recognition of shifts in mineral markets and commodities has forced a need for major adjustment in the mining industry to meet market realities. Specialty metals used in chemical, electronic, ceramic, and alloy markets have been identified as having high growth potential, however, these commodities mean a drastic change in the mining sectors expertise.

Specialty metal markets require production of high purity metals and/or chemical derivatives. In some market specifications, gallium for example, a purity of 99.9999% Ga is required (known as 6N purity, six nines). In order to produce refined metals of this nature, the mining industry requires the technical capability to chemically alter ores to finished states in addition to the expertise in chemical marketing.

In the past, the mining industry has been thought of as resource base companies (exploration and removing ore from the ground), whereas today, companies are incorporating add-on processing technologies to improve on mine cash flows and/or to meet market demand and specifications. Companies, such as Molycorp, E.I. du Pont, Asarco Inc., Union Carbide, etc., have developed fully integrated mining operations producing refined metal-chemical products. The most recent example of fully integrated processing of ores is the recent move by Canada Tungsten, mining

scheelite in the Northwest Territories and marketing-processing scheelite to ammonium paratungstate at the Fort Madison, Iowa, U.S.A. processing plant.

For the last three years, there has been a noticable change in some companies business opportunities reflectng marketing strategies, however, a major evolution of the mining industry (as a whole) towards specialty markets has not been recognized. An example of a company to undergo a "change" in business opportunities includes Amax and their strategy on molybdenum marketing. Amax had a reputation for producing high volume metals where around 1985 the move to produce molybdenum-based chemicals resulted in the evolution of a specialty chemical producer. Since then, the company is alert for other opportunities in metal-based chemicals, focusing in on high growth areas. This change to higher-valued-added specialty fields, results from the development of new technologies, as well as, marketing expertise.

A limitation to the developments in New Brunswick, with respect to fully integrated processing, has been related to the identification of market potentials. In most cases, the fully integrated processing of ores requires in-house know-how (which most multinational companies have in place). In the recognition of market potentials, the possible supply of raw materials has to be identified locally in order to establish economic growth by integrated processing opportunities.

Research Strategy

A majority of the research over the last decade, related to ore processing within New Brunswick, has been geared towards the support of the mining industry. Industry relies on local research to support operations and is solely "applied type" research to resolve processing bottlenecks. Applied research leading to the opening of a mine in New Brunswick has been non-existant. The track record for the relationship between industrial development and research has been poor, due solely to the lack of communication and the awareness of opportunities. Various strategies are currently in place to improve on this situation, such as MPIP and MISP development programs. It has been recognized that the following items have to be established to optimize on research productivity:

a. Cost Effectiveness: there are various factors relating to cost effectiveness, however, the most predominant factor being research oriented to the best suited technology for commercial and economic practicality.

b. Expertise: researchers must have an insight into the technical considerations for commercialized concepts, which includes skills in laboratory-pilot plant methodology, engineering scale-up and cost analysis, and have a good feel for overall development concepts, such as marketing-economic interpretation and resource delineation. In addition to technical skills, productive resource research results from an innovative work force.

c. Co-op Structuring: referring to communication and work related to a common objective between various organizations such as government, universities, industry, and research and development institutions. For each organization,

an area of expertise or specialization will provide more productive research, as opposed to each organization having diversified expertise in applied and fundamental research and development. Because of the net population and net demand from industry being lower than other regions of Canada, the concept of co-op research and development for the Atlantic region may be more cost effective than just in New Brunswick for the mining sector (similar to research and development being carried out by forestry in the Atlantic region).

Mineral Processing Investigations Program

The studies being carried out by the Process Studies Group under MPIP deal with seed development concepts in an integrated approach. A knowledge of ore separation characteristics and probable markets are used to evaluate processing options for the development of a mineral industry in New Brunswick. Through these low cost incubator-type studies, concepts for further research are established and commercial development opportunities are identified. Concepts that are presently limiting the development and optimization of New Brunswick resources are briefly discussed in the Process Studies Quarterly Progress Report, September 30, 1987.

NOTE: Concepts for further research and opportunities for commercial development are a part of studies worked on to date by the Process Studies Group. The list of ideas have been derived through bench-scale test work and/or engineering-marketing feasibility studies. These concepts are not a complete list of development areas in New Brunswick.

Various opportunities for commercial development have been outlined in Figure 1 and Table 1 for various regions of New Brunswick. These concepts are derived through the studies being administered by the Process Studies Group. Each concept is described by the opportunity

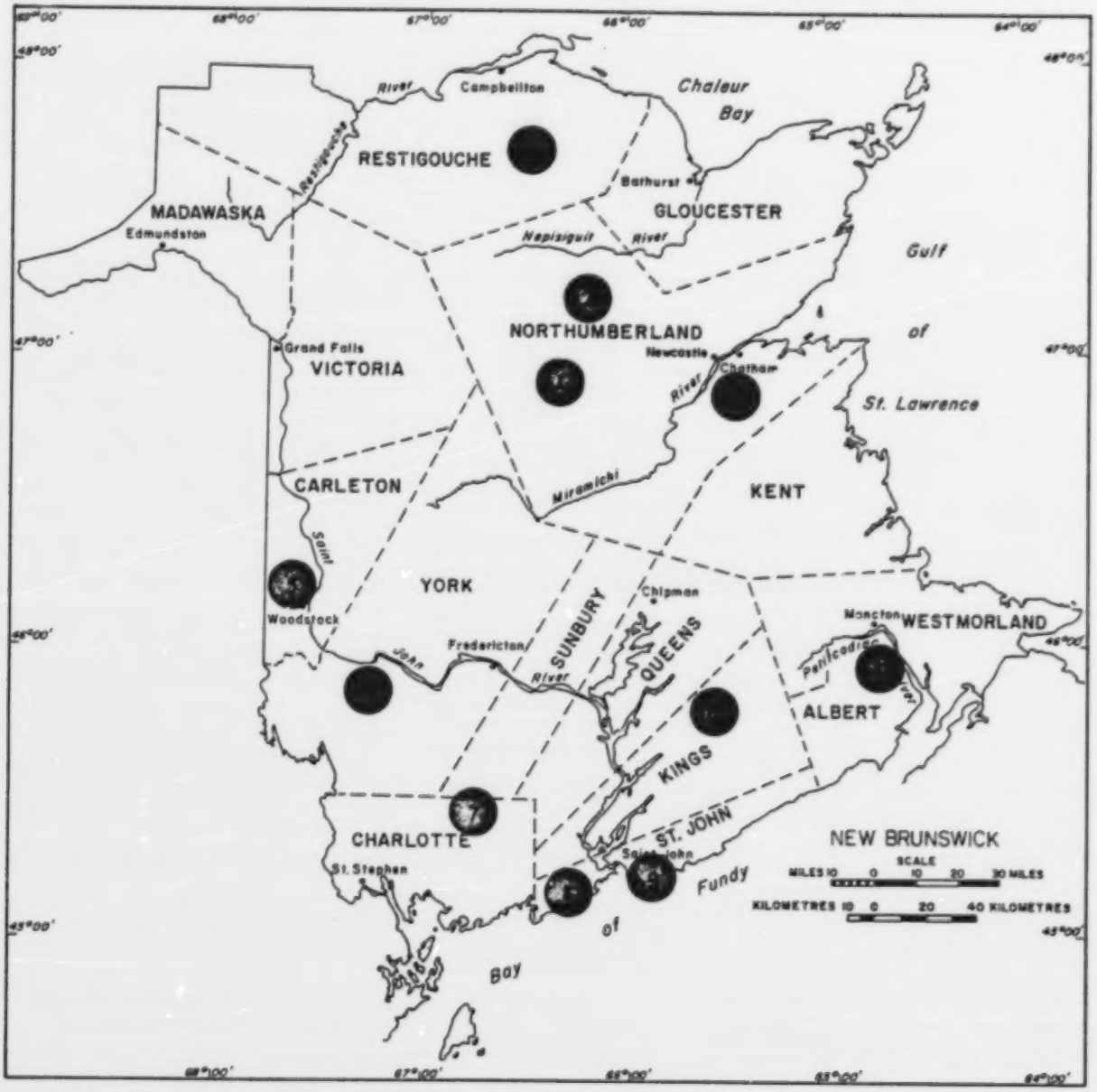


FIGURE 1: Development concepts for New Brunswick: (1) custom mill for chemical extraction of refractory gold ores, (2) custom mill for chemical upgrading of bulk sulfide concentrates, (3) physical chemical extraction of phosphate and rare earths, (4) chemical refinery for low tonnage high revenue metals (i.e., rare earths), (5) dump leach extraction of manganese, (6) antimony oxide production plant, (7) ammonium paratungstate production facility, (8) synthetic magnesium oxide production, (9) heap leach of gold ores, (10) production of potassium sulfate, (11) physical upgrading of ilmenite (titanium).

TABLE I: COMMERCIAL DEVELOPMENT OPPORTUNITIES OF NEW BRUNSWICK MINERAL RESOURCES

(Diversifying the Existing Industry)

DEVELOPMENT CONCEPT	OPPORTUNITY PROFILE	ESTIMATED INVESTMENT/JOBS	STATUS/LIMITATIONS
1. Custom mill for refractory gold ore and concentrates.	A centralized processing plant to treat gold ores and concentrates that are considered refractory (gold not recovered by conventional cyanization). A limitation to the development of various refractory gold ore deposits is the large capital outlay for a chemical processing plant. This concept looks at the possibility of localized physical upgrading of ore and sale of concentrate to a custom mill. Market: precious metal, dore	For about 10-15,000 oz Au/yr, an estimated investment for chemical processing as a localized facility is around $50-100 million, employing 50-100. Local installations for physical upgrading may employ 20-50 with a capital of $10-50 million, depending on the situation. NOTE: Various physical upgrading plants may be established to provide local concentrates containing 20-40 g/t Au.	Ore types have been identified and technology for custom processing to be identified along with various resource base tonnages.
2. Bulk sulfide for custom mill	A centralized base metal chemical processing plant capable of converting bulk sulfide concentrates (produced at separate locations within the province) into refined zinc metal and various by-products. Market: high purity zinc metal, chemical derivatives of lead and copper (possibly silver and gold)	For the production of 100,000 t Zn/yr, capital cost estimate of $125-190 million, employing 150-200.	Various processing methods have been developed and some piloted. The technology for treating complex sulfide concentrates requires some flexibility on feedstock grade, where an adaptable technology has to be identified with an attractive profitability and limited environmental constraints.
3. Phosphate and rare earth extraction plant	A physical upgrading of phosphate (apatite) and the chemical extraction of rare earths to produce a phosphate rock, yttrium and rare earth concentrates Market: Phosphate for fertilizer and rare earth concentrates (chemical, electronics)	For the treatment of about 200,000 t/yr of ore, capital estimate of $50-75 million for phosphate benefication and about $5-15 million for chemical extraction of rare earths, employing a total of 50-100.	The apatite at Benjamin River is known as an occurrence and further identification of the resource will be required. Concepts of extraction technology have been identified and require further development. One major limitation is to identify overall tonnage and grades of P_2O_5, Y_2O_3 and rare earth oxides.
4. Rare earth metal refinery	A chemical refinery capable of treating possibly rare earth concentrates (i.e., 60% REO's as feedstock, where the refinery is capable of producing high purity metals of yttrium, lanthanum, cesium, neodymium, samarium, etc.). A refinery of this type would be capable of treating concentrates shipped from the Great Lakes or other internationalsources. Market: Refine Lanthanide metals (electronics)	For the treatment of about 1,000 tonnes of concentrate per year, capital estimate of $20-50 million for processing equipment with significant automation, employing 50-75.	A concept for former sulfation roast pilot plant. A major limitation is the technology for separation of rare earth oxides and developing a market (i.e., market in high tech manufacturing).
5. Dump leach of manganese ores and purification plant	A chemical treatment facility using low cost dump leaching to extract manganese from crushed ore and the separation-precipitation and/or electrowinning of metals in solution to produce manganese dioxide. Market: manganese dioxide (batteries), possibly manganese sulfate, manganese hydroxide (chemical)	For the production of 10,000 tonnes per year of Mn contained in product, capital cost of $50-100 million employing 50-75.	Bench scale work and preliminary capital—operating cost identified. Development required on technology and operating cost to produce high purity solutions for electrowin of manganese dioxide (establishing a low cost operation is required because of low grade ore).

DEVELOPMENT CONCEPT	OPPORTUNITY PROFILE	ESTIMATED INVESTMENT/JOBS	STATUS/LIMITATIONS
6. Antimony oxide production plant	A chemical processing plant capable of producing high purity antimony oxide from antimony sulfide concentrates. Market: antimony oxides (chemical, flame retardants)	For the production of 10 M pounds of oxide annually, capital cost of $5-10 million, employing 20-25.	Preliminary bench scale work on processing technology. Optimization of processing method and establishing sales of products.
7. Ammonium paratungstate (APT) production plant	A physical and chemical processing plant capable of producing ammonium paratungstate from Mount Pleasant tungsten ores. This plant includes a gravity separation circuit and a chemical treatment plant to produce APT as opposed to the upgrading and sale of wolframite ($FeWO_4$) concentrates. Market: APT (metal and alloy industries)	For the treatment of 725,000 tonnes of ore annually, capital cost of $15-20 million for gravity plant and $5-10 million for chemical plant, employing 100-150 in total.	Preliminary bench scale work on processing methods. Identification of technology for purification of leach solutions. Price of metal at an all-time low.
8. Synthetic magnesium oxide production plant	A chemical processing plant capable of recovering magnesium from dolomitic ores (Ca,Mg,CO_3) and producing high purity synthetic magnesium oxide. Seawater is used as an additional source of magnesium where 50% of Mg in product is derived from seawater. Market: MgO (chemical, refractories, metal, and electronics	For the treatment of 145,000 tonnes of dolomite and 900,000 tonnes of seawater annually, capital cost of $30-50 million, employing 50-75.	Technology is commercial, where further development is required to optimize on operating conditions. Development of product sales.
9. Heap leach of Cape Spencer ores	A chemical treatment facility using low cost heap leach method to extract gold from ore and recovering gold from solution using zinc precipitate or carbon adsorption.	For the treatment of 200,000 tonnes of ore annually, capital cost of $3-5 million, employing 20-30.	Further identification of ore and development of suitable technology for gold recovery and meeting environmental standards on effluent is presently being carried out. Resource identification.
10. Potassium sulfate production plant	A chemical processing plant converting potash to potassium sulfate using gypsum as a source of sulfate. Calcium chloride is produced as a by-product. Market: potassium sulfate for fertilizer and calcium chloride as road salt	For the production of 30,000 tonnes per year of potassium sulfate, capital cost estimate of $15-20 million, employing 40-60.	Technology has been bench tested where further testing to develop operating conditions. Development of product sales.
11. Titanium upgrading mill	A physical upgrading plant capable of producing ilmenite concentrate from hard rock hematite-ilmenite ores. The possibility of producing chemical grade TiO_2 pigment from ilmenite concentrate is an additional development opportunity. The production of ilmenite concentrates may be done by a combination of gravity, magnetic separation, and flotation. Market: ilmenite concentrate for pigment producers	For the treatment of 725,000 tonnes of ore annually, capital cost of $20-50 million for benefication plant, employing 50-75.	Further identification of ore required (known presently as an occurence) and methods of upgrading have to be identified. Resource and market identification. Possible sources of other titanium bearing rock to be identified (i.e., anatase or rutile).

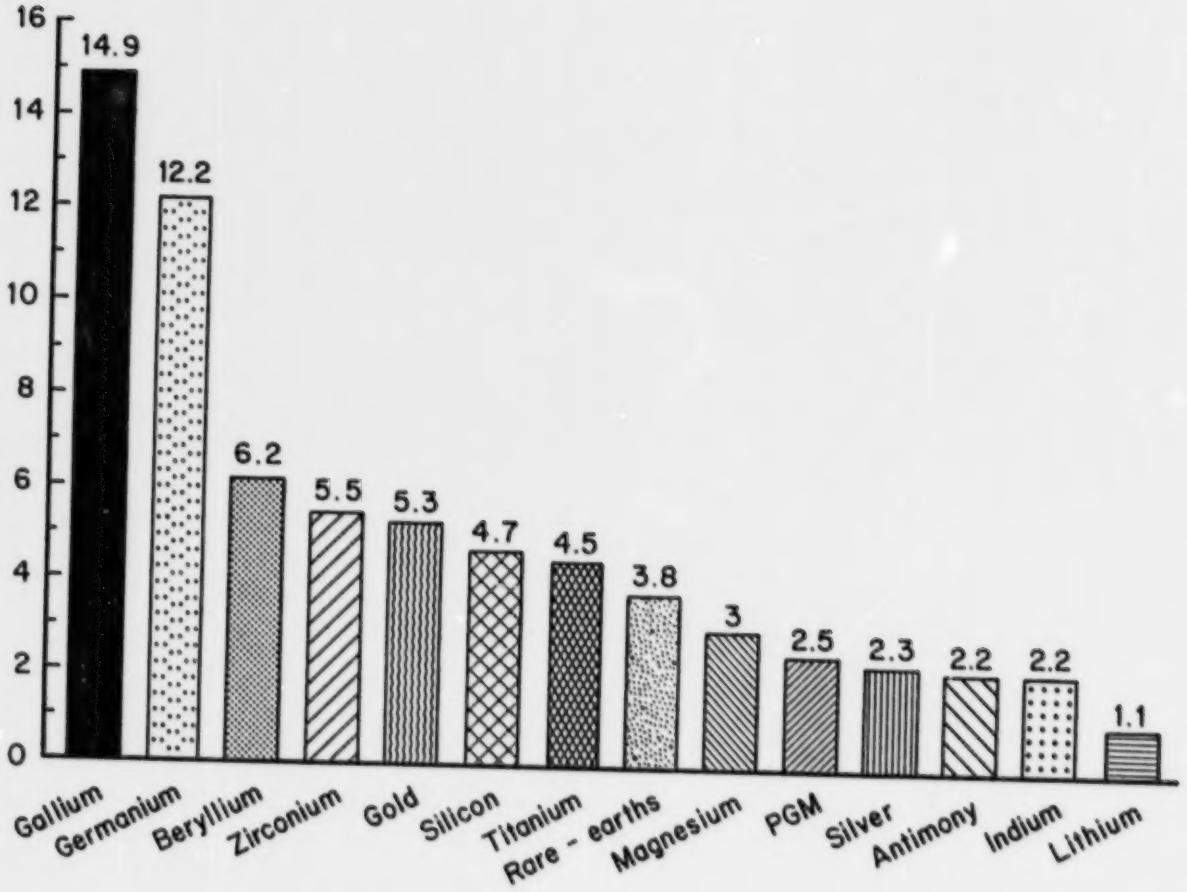
profile as outlined in Table 1, where detailed reports are/or will be made available through DNR&E's open file system. These concepts are at various stages of development, where some concepts require further identification of the resource tonnage and grade. To date, a majority of these concepts are at the primary development stage, where establishing one concept as a commercial operation would have significant economic benefits to New Brunswick.

Under the Mineral Development Agreement (MDA), studies have been completed on bench-scale testing and cost analysis for dump leaching of manganese ores (No. 5) and further studies on potassium sulfate production (No. 10) is currently being carried out. Initial testing of ores or concentrates has been carried out under the MPIP for all concepts outlined in Table 1. It is anticipated that further contract research under the MDA will be carried out to develop gold processing technology pertaining to refractory and Cape Spencer ores (No. 1 and No. 9). The following Projects are presently being carried out under MPIP.

Extraction Possibilities of Specialty Metals

The concept possibility of developing specialty metals in New Brunswick, would help to establish a diversification of the mineral industry. The project originates from a marketing report and discussions with Kline and Company Inc. of New Jersey. The study done by Kline on the growth potential of 14 metals, outlined in Figure 2, resulted from published market data and from discussions with various companies in the U.S. In discussions with Kline, the following questions were discussed:

U.S. OUTLOOK FOR SPECIALTY METALS BY METALS
Percent per year, 1985 - 1990



Kline & Company, Inc.

FIGURE 2: Annual growth (percentage) for demand of specialty metals.

A. Why is there limited development in Canada and the United States with respect to these metals?

* no industrialized theme or strategy on behalf of Governments where there is no insight to future metal markets.

* Canada is sometimes considered by investors as the little brother of U.S. and no expertise has been developed in Canada on downstream processing (or at least major investors in the U.S. think this way and conceive Canada as the great white north where processing may be very costly because of climatic conditions).

* large multinational companies that contain expertise to develop such resources are solely owned by U.S. investors.

B. What advantages does New Brunswick have with respect to incentives for investment?

* Major advantage to other nations or other locations would be to guarantee a supply of raw material from a politically stable region. The raw material being a co-product from a resource may not be attractive where a long term steady stream of raw materials is required.

* Incentives such as tax advantages, cheap source of energy, and employment (skilled labour forces) are all considered by main investors.

As a result of identifying the long term development potential of these metals (as indicated in Figure 2), various studies have been carried out under MPIP to review the commercial development potential of gallium, titanium, rare earths, and magnesium in New Brunswick. In addition to the MPIP studies, a project is presently being carried out relating specialty metals to the geological environments of New Brunswick.

A forecast of demands for gallium metal and compounds are considered to have the highest growth potential in mining and chemical industries, where gallium is predominantly associated with the electronics industry (i.e., bubble memories and solid state electronic applications). The demands for this metal has recently become significant and major producers of gallium are very few. Rhone-Poulenc of France is the largest producer of around 20 tonnes annually where plans for expansion in Australia and the U.S.A. will increase capacity. Major developments in gallium recovery from ores have been reported from Japan where the major sources of gallium are byproducts of aluminum smelting and electrolytic zinc plants. The major producers in North America have been outlined in Table 2. In 1983, the production of gallium from North America was 12.4% of world production around 16,500 kg.

In New Brunswick, the production potential of gallium from our resources has been found to be limited where levels of gallium occur in the range of 50-100 ppm with most ores. The most promising source of gallium, identified to date, has been ash from coal combustion units. The technology (state-of-the-art) to recover various metals (including gallium from fly ash) has been reviewed by Ames Laboratory at the Iowa State University, however, the commercialization of these processes has not been acknowledged.

TABLE 2: Gallium Metal Production from Mineral Resources of North America

COMPANY NAME	TONNAGE YEAR	ORE TYPE	FEEDSTOCK (GRADE)	Ga PRODUCED (t/year)	PURITY OF Ga (7N)	COMMENTS (PROCESSING)
MUSTO Exploration St. George, Utah	100t/day ore processing (start production in 1986)	Copper mine by-product	243,000t @ 0.039% gallium 0.064% germanium 1.63% copper (390ppm Gu)	10 t/year metal	3N metal	Ore is crushed, ground and leached then processed for Cu, Pb, Zn, Ag, etc. Tails are CCD washed, H_2SO_4 leach (3 stage) pregnant solution is SX to recover Ga and Zn after purification. Process is similar to uranium extraction.
Rhone-Poulenc Freeport, Texas	N/A	N/A	N/A	N/A	6N/7N metal & prod.	Not in operation. Plans to go into production.
Eagle Picher Industries, Inc. Miami, Florida	N/A	Zinc refining by-product	By-product of Zn refining	Small scale 1-200 $\frac{kg}{yr}$	N/A	Ga is a by-product of the zinc operation or gallium scrap
Alcoa Bauxite, Arizona	N/A	Aluminum ore Bauxite	N/A	4-5 t/yr	N/A	-Gallium was extracted during aluminum processing -Stopped production in 1982
Cominco Ltd. Trail, B.C.	250,000t/yr of zinc metal	By-product from zinc ore process or scrap metal	N/A	apprx. 300kg/yr	high purity	Gallium arsenide LEC crystals or pure metal. -Ga recovered from Zn ore. -By-product of zinc processing.
Alcan Aluminum Ltd. 1188 Sherbrooke Street, West Montreal, Quebec	By-product of aluminum production	By-product of aluminum production	(range of 30-100ppm Ga in recycle solutions)	5 to 10t/yr	3, 4, 6, 7, and 8N purity	-6N is used in LEC crystals of gallium arsenide and gallium phosphite. -7N is semiconductor grade by-product of aluminum processing.
Tanco Tantalum Mining Corp. of Canada Ltd.	N/A	By-product from tailings	Tailings of feldspar and micas contained gallium (500ppm)	N/A	N/A	-Mine closed in 1982 due to depressed tantalum markets. -By-product of tantalum.
Highwood Resources Limited Calgary, Alberta	Not in production	Deposit 1000' x 30' x 500'	Ore deposit 0.66% BeO 1% niobium oxide 0.05% gallium (500ppm)	N/A	N/A	Joint venture with Hecla Mining Co. (Idaho) for commercial development.

On the other hand, the concept of developing a refinery in New Brunswick has its possibilities in upgrading or purifying crude metal (i.e., alternative to concept four of Table 1). Recently, Rhone-Poulenc has announced plans to build a large refinery at Freeport, Texas, having a capacity to produce over 50 t/y of 6N/7N gallium. The prospect of developing a gallium industry in New Brunswick has not been reviewed, however, interesting possibilities exist. Nova Crystals of Halifax has begun development in the production technology of manufactured gallium arsenide crystals, which provides a seed to establishing a possible industry in the Maritimes.

The supply of titanium containing ores and concentrates has interesting commercial opportunities in North America. The opportunity that is predominant with most processors in North America, as outlined in Table 3, is to procure the cheapest raw material source. In the U.S.A., where most pigment plants are located, the processors are dependant on imported ores and concentrates. The U.S.A.'s paper industry and Japan's plastics industry accounts for a large share of the pigment market.

Ilmenite ($FeTiO_3$) has been found in New Brunswick near Moncton, known as the Lower Coverdale Titanium occurrence. This occurrence does occur as an outcrop, however, grades are not considered economic near surface. Preliminary separation tests done on the low grade core has indicated a typical association of ilmenite and magnetite, where a combination of gravity, flotation and magnetic separation will be required to physically

TABLE 3: Titanium Mineral Production from Resources of North America

COMPANY NAME LOCATION	TONNAGE (tons/year)	ORE TYPE	FEEDSTOCK (GRADE)	PRODUCT PRODUCED (tons/year)	PURITY OF PRODUCT	COMMENTS (PROCESSING)
Quebec Iron and Titanium Corp. (QIT Fer et Titane Inc.) Sorel, Quebec Canada	850,000 of ore	ilmenite-haematite deposit	ore averaging 82% combined iron and titanium oxides	low manganese pig iron Sorelmetal and titania slag	slag 80% TiO_2	ore is crushed and upgraded by heavy media and gravity separation, calcined and smelted in arc furnaces.
Trioxide Canada Tracy, Quebec Canada	37,000 of feedstock	N/A	slag 80% TiO_2	N/A	TiO_2 pigment grade	Use sulfate process using slag from Sorel as raw material.
NL Chemicals Varennes, Quebec Canada	36,000 of feedstock	N/A	slag 80% TiO_2	N/A	TiO_2 pigment grade	Use sulfate process using slag from Sorel as raw material. Chloride processing plant to be added to existing plant.
E.I. du Pont de Nemours & Co. Ltd. *Starke, Florida, USA *Highland, Florida, USA Antioch, California(1) Delisle, Mississippi(2) Edge Moore, Delaware(3) New Johnsonville, Tennessee(4)	ore N/A (200,000 of feedstock processed at Starke) (1) 32,000 (2)136,000 (3)100,000 (4)207,000	ilmenite (mines are 18 miles wide and 25-70' deep)	60% TiO_2 (purchase of ilmenite from various sources)	475,000 TiO_2 (both plants in Mexico and USA supply 20% of world capacity having an annual capacity of 550,000 t)	pigment grade	Ore is removed by dredging and upgraded on a mobile plant floating. The dredge concentrate shipped to Starke dry plant for separation of ilmenite, zircon, staurolite, (Fe, Mg silicates) and aluminum silicates (success due to chloride processing employing low grade concentrates < 60% TiO_2).
Associated Minerals (USA) Inc. Green Cove Springs Florida, USA	228,859 of ore	N/A	N/A	25,000 t rutile 50,000 t ilmenite	N/A production of ilmenite, rutile, zircon, monazite, staurolite.	Gravity separation, dry high tension separation.

COMPANY NAME LOCATION	TONNAGE (tons/year)	ORE TYPE	FEEDSTOCK (GRADE)	PRODUCT PRODUCED (tons/year)	PURITY OF PRODUCT	COMMENTS (PROCESSING)
N.L. Industries Inc. Tahawus, New York USA (production suspended in 1984)	10,000-100,000 of ore	titaniferous magnetite deposit (open pit mining)	N/A	N/A (also produce magnetite as by-product)	ilmenite concentrate 45% TiO_2	Ore upgraded by a combination of gravity, low and high intensity magnetic separation. The non-magnetic fraction is treated by flotation.
Asarco Inc. Manchester, New Jersey, USA (shut down in March 1982)	N/A	N/A	N/A	170,000 t (until closure, plant capacity related to 24% of the country's capacity of ilmenite)	63% TiO_2	Ore recovered by a floating suction dredge and upgraded by a land-based concentrator.

upgrade the ore. Because of an integration of various physical separation stages, an ore grade in the range of 30-40% TiO_2 would be considered as having commercial potential for the sale of concentrates.

The demand for high purity separated rare earth metals has risen, where the price of metals is up to one thousand times those of mixed concentrates. Hence, the demand for rare earths is related to the growth of high purity oxides, Japan being the largest consumer. Main areas for growth in rare earth demand are samarium oxide used in permanent magnets and yttrium-europium oxides used in phosphors for coloured television tubes, x-ray intensifying screens, fluorescent lamps, and lasers. Recent breakthroughs in the discovery of gadolinium/barium/copper oxides and yttrium/barium/copper oxides, for ceramic superconductors has aroused the interest of REO producers, but the application of superconductors may be regarded as a long-term commercial opportunity.

In North America, the major refineries for rare earth metals, as outlined in Table 4, include Molycorp and Rhone-Poulenc. As noted recently, Molycorp plans to spend $20 million over the next five years to improve their position in downstream refined materials. In the rare earth industry, competitiveness relates to the ability to produce high pure metals. In Canada, the rare earths reserves are large in the Elliot Lake district of Ontario and Strange Lake on the Quebec-Labrador border. As noted in Table 4, there is no predominant refining operation for REO concentrates in Canada (note that Sherritt Gordon Mines produce a

TABLE 4: Major Yttrium and Rare Earth Refineries of North America

COMPANY NAME LOCATION	TONNAGE (tons/year)	ORE TYPE	FEEDSTOCK (GRADE)	REO PRODUCED (tons/year)	PURITY OF Metal	COMMENTS (PROCESSING)
Molycorp Inc. Mountain Pass, California	N/A	N/A	85% REO Calcined Concentrate	100 t/yr samarium oxide 40 t/yr gadolinium, terbium and europium oxides	All 95-99.99%	Mountain Pass California Plant. The REO concentrate undergoes SX to separate the light and heavy rare earths. Both heavy and light products undergo further SX to separate out the various products.
Molycorp Inc. Louviers, Colorado York, Pennsylvania, and Washington	N/A	N/A	A portion of the light REO SX product from the Mountain Pass Plant (Colorado plant)	33 t/yr samarian metal and neodium metal (Washington plant) 80 t/y Y_2O_3 (Colorado plant)	96% Nd	Samarium oxide converted to samarium metal and alloys by heating in controlled atmospheric induction furnaces. Nd produced by calciothermic reduction.
Davison Specialty Chemical Co. Chattanooga, Tennessee	N/A	N/A	N/A	N/A	N/A	Produce high purity rare earth oxides, rare earth oxides rare earth compounds and glass polishing powders. Produce synthetic zeolites containing rare earths used in petroleum catalytic cracking refineries.
Rhone-Poulenc Inc. Freeport, Texas	Greater than 7000 TPA of concentrates	Rare earth concentrates	N/A	N/A	N/A	Freeport, Texas plant treats concentrates from parent company in France using a liquid-liquid extraction process. Produces low grade rare earths which are sent to La Rochelle for further refining.
Rhone-Poulenc Inc. Mineville, New York	N/A	Iron ore tailings	Iron ore tailings	N/A	N/A	Plans to set up a rare earth extraction unit on site at the former Iron Ore mine of Mineville, New York.
Research Chemical Co. Phoenix, Arizona	N/A	Residues from France and Malaysia	60% yttrium oxide 95% cesium, lanthanum, neodymium and praeseodymium oxides	35 t/year neodymium	N/A	Produce large amounts of samarium and lanthanum.

COMPANY NAME LOCATION	TONNAGE (tons/year)	ORE TYPE	FEEDSTOCK (GRADE)	REO PRODUCED (tons/year)	PURITY OF Metal	COMMENTS (PROCESSING)
Transelco Division of Ferro Corp. Penn Yan, NY	N/A	Bastnaesite	Bastnaesite	N/A	N/A	Produce rare earths for optical, electronic, ceramic and chemical markets.
Shieldalloy Corp. Newfield, NJ	N/A	Bastnaesite concentrates from Molycorp and some rare earth chloride in solution	Bastnaesite concentrates and rare earths in chloride solution	N/A	N/A	Produce glass polishing powders for opthalmic lenses and precision parts.
Ronson Metals Corp. Newark, NJ	N/A	Monazite bastnaesite	Rare earth chlorides	Misch metal, lanthanum, cesium, and didymium (Nd + Pr) alloys. Samarium metal in ingots, tube and powder form. Neodymium in the form of metal and ingots. (35 TPA Nd)	N/A	N/A
Reactive Metals and Alloys Corp. Pittsburg, Pennsylania	N/A	Rare earth chlorides from Molycorp	Rare earth chlorides from Molycorp	1820 TPA misch metal Rare earth silicide	Rare earth silicide (33% rare earths)	The company produces various grades of rare silicide, single ladle desulphurizing compounds and other specialty alloys for the iron and steel industry. A joint venture is planned with Mitsubishi Metal Corp. of Japan to research, market, and develop neodymium metal, alloys, and other rare earth metal products.
American Metallurgical Co., Inc. Springdale, PA	N/A	Bastnaesite from Molycorp	Bastnaesite from Molycorp	Rare earth silica 2300 TPA	30-50% rare earth metals	Output is sold to manufacturers of high-strength low-alloy steel and high-performance alloys.

COMPANY NAME LOCATION	TONNAGE (tons/year)	ORE TYPE	FEEDSTOCK (GRADE)	REO PRODUCED (tons/year)	PURITY OF Metal	COMMENTS (PROCESSING)
Crucible Magnets Elizabethtown, KY	36,000 TPA	Samarium cobalt alloy from Goldschmidt of West Germany	Samarium cobalt alloy	Samarium-cobalt permanent magnets	N/A	Have produced neodymium-iron-boron magnets on a pilot plant scale since March 1984.
Hitachi Magnetics Co. Edmore, MI	N/A	Samarium oxide in powder form from Rhone-Poulenc or Molycorp	Samarium oxide	Samarium-cobalt magnets	N/A	N/A
IG Technologies Inc.	N/A	N/A	N/A	Rare earth cobalt magnets	N/A	Also produce research quantities of neogymium-iron-boron magnets at Valparaiso, Indiana.
Elektron Energy Landisville, PA	N/A	Samarium metal and samarium extracted from misch metal residues	Samarium	Samarium-cobalt alloys	N/A	Produce samarium-cobalt alloys by a melting process, for use in their own manufacture of magnets.
Thomas and Skinner Inc.	N/A	N/A	N/A	N/A	N/A	Produce rare earth cobalt permanent magnet alloys at Indianapolis, Indiana
General Motors Corp. Detroit, MI	N/A	N/A	N/A	Neodymium-iron-boron magnets	N/A	Produce neodymium-iron-boron magnets and "Magnequench" alloy using a rapid solidification process.

samarium-cobalt alloy powder at Fort Saskatchewan in Alberta for permanent magnets) for aerospace and electronic applications. From 1966 to 1977, when mining ceased, yttrium concentrates between 30 and 35% Y_2O_3 were produced by Denison, Rio Algom, Stanrock Uranium Mines, and Multi Minerals. Denison now produces 100-150 t/a of yttrium concentrates, where Molycorp refines 50% of output at Louviers, Colorado and Japanese companies refine the remainder.

As indicated in Table 1, a development concept for New Brunswick could include a rare earth refinery (concept No. 4) as well as the possibility of extracting rare earths from an apatite occurrence found at Benjamin River (concept No. 3 of Table 1). To date, the concept for a refinery has not been studied in detail, where the technology of rare earth refining and knowledge of rare earths has been a major limitation to local investment and development.

As part of identifying development opportunities for rare earths in New Brunswick, the Benjamin River apatite occurrence, to date, has been regarded as the most probable opportunity. Bench-scale tests done on the rare earths found in the Mt. Pleasant ores revealed these rare earths are fairly refractory (fine mineralization of cesium-lanthanum fluorcarbonates enclosed with fluorite) where recovery by chemical extraction was not viable. Preliminary bench testing of the Benjamin River occurrence has indicated that the phosphate and rare earths can be

physically upgraded with recoveries in excess of 85% by phosphate flotation techniques. In addition to flotation, the extraction of yttrium and cesium was quite successful using dilute sulfuric acid at room temperature.

The preliminary test work on Benjamin River has indicated some positive development opportunities, where further work will be required to characterize the rare earth-phosphate extraction flowsheet. It may be possible that this occurrence is similar to the light rare earths associated with the apatite-rich carbonates of Ontario and Quebec, and the potential of developing this occurrence will depend on the distribution of rare earth metals. It has been recognized that further work on the delineation of this occurrence will be required before any further development of processing technology takes place.

In reviewing the developing possibilities of dolomite type ores, particularly ores located near seawater, the production of magnesium oxide (MgO) has commercial opportunities. The concept of producing high purity synthetic magnesia in New Brunswick has been considered more logical than the production of magnesium metal. It is believed that with various smelting operations going into production in Canada and the U.S.A., the increased supply of metal will result in a very competitive market.

The major uses of high purity magnesium oxide are chemical (or as a possible feedstock for a magnesium metal plant), high performance refractories for furnace linings, and fused magnesia used as electrical insulators. The concept presently being bench tested, as outlined in development concept No. 8 of Table 1, produces MgO from seawater and calcined dolomite. The process has been found to be quite successful in producing MgO at 95-97%, however, specification on CaO has not been met. This is believed to be related to optimizing operating conditions such as water to solid ratio and resistance time of water hydrolysis reactions and washing methods of hydrolysis products.

It is probable that there is a local chemical market for high grade MgO used for agricultural purposes and in pulp and paper production. In order to produce high performance refractories and fused magnesia, additional energy intensive processing methods are used. Refractories and fused magnesia are considered at this point as add-on capabilities that does require technological development to produce a product of marketable specifications. Further work will be required to establish a local market.

Process Development on Mount Pleasant Tungsten Ores

It is interesting to note the reserve base data published by USBM has indicated that Canada has the largest tungsten reserves in North America and is second to the world's largest in China. The resource base in New Brunswick is considered low grade wolframite where run of mine ore at Mount Pleasant averages around 0.38% WO_3, with recoverable ore reserves of about 7.02 million tonnes.

In addition to the resource base, it is interesting to note that there is no production facilities for ammonium paratungstate (APT) in Canada. The production of APT is the center of the tungsten industry where APT is used to produce tungsten chemicals and ceramics, superalloys, carbide tools, and metal products. Various APT production facilities are outlined in Table 5. Union Carbide has a fairly large operation in California. Information on APT plants in China is limited, however, nine APT plants have been reported to be in operation.

The term "integrated plant" refers to the various physical and chemical processing unit operations necessary to produce ammonium paratungstate form ores. Union Carbide went with a fully integrated plant in 1959 and since then, a number of producers followed this lead, including Amax and General Electric. The processing of ores to APT is considered financially preferable to selling concentrates due to the low grade nature of the ores. It is anticipated that operations of the future will consist of totally integrated plants that will yield high purity products.

The major difficulty with the production of wolframite concentrates, as experienced by the Billiton operation at Mount Pleasant, was to meet grade specifications of final concentrate. The relatively high levels of impurities (such as arsenic, silica, molybdenum, and phosphorous) make it difficult to sell concentrate, where few converters worldwide are able to handle the material in unblended form.

TABLE 5: World Ammonium Paratungstate Production Plants
(Published Literature)

COMPANY/LOCATION	FEEDSTOCK GRADES/TONNAGE	PRODUCTS PRODUCED	COMMENTS ON PROCESSING METHDS
Seco-Titan PTY Ltd., Australia	Use over 100 tonnes of tungsten per year, use domestic concentrates for feedstock.	Production of APT and tungsten carbides for tools.	Processing methods not reported.
Wolfram Berglau, Austria	Scheelite concentrates are trucked to conversion plant at Berglau. About 260,000 tpa of concentrates are produced from ore of grade 0.79% WO_3 mined in an open pit.	Capacity of 1,350 tpa of tungsten metal and carbide powder.	One of the few processing plants to convert ore to intermediates of tungsten in addition to Union Carbide USA and KTMC Korea. Plant came on stream in 1977.
Zhuzhou, China	NOTE: the Zhuzhou plant may be considered as one of the largest tungsten plants in China. There are a total of 9 APT plants reported in China (i.e., Zigzong, Huzon) from which small quantities are exported.	Plant has an annual capacity of 2,500 t of APT and 1,500 t of sintered carbide.	Known as a fully integrated plant, producing products from ores.
Herman C. Starck, West Germany	Designed to use feed from all forms of tungsten, including scrap.	Biggest producer of metal powder, carbide powder, trioxide, acid, APT and salts of tungsten	
Korea Tungsten Mining Co. Ltd. (KTMC) Sangdong, Korea	Milling capacity of 2,000 tpd ore producing 70% WO_3 concentrate. Producing 80-90% of Korea's output.	Concentrates are processed to tungsten powder, carbides and APT. Annual capacity of 1,500 t APT.	Fully integrated plant.
Union Carbide (Uneto Minerals Corp.) Pine Creek, California USA	Low grade concentrates produced at mine site, together with brought-in concentrates are processed to APT, near Bishop, California. (Concentrates 20% WO_3 is treated from Strawberry Mine)	Production tonnages not reported (Mine production at Pine Creek being the largest in USA is about 0.5-1 Mtpa)	APT plant capable of treating both wolframite and scheelite concentrates. NOTE: Processing concentrates to APT is financially preferable to selling concentrates due to the low grade nature of the ore. Union Carbide developed the soda autoclave process.
Amax Fort Madison, Iowa USA	Treats low grade concentrates (scheelite from Northwest Territories, Canada).	Production of APT and blue tungsten oxides, capacity of 1,000 tpa W (equal to 1,543 tpa APT).	Considered a fully integrated plant since 1980. (In 1986, Amax sold its interest to Canada Tungsten, which is now responsible for marketing its own products and now operates the Fort Madison Plant).
General Electric Corp. Utah, USA	Operation planned to have a capacity of 725 t concentrate (W content).	Production of APT to be used classively by GEC for the production of tungsten wire and carbide powder.	Processing methods not published.

In reviewing the development options for tungsten at Mount Pleasant, the processing of ores using a gravity circuit combined with chemical processing technology to produce high purity APT has been identified as a development concept (as outlined in Table 1, No. 7). Based on the detailed mineralogy of ore and concentrates and the limitations experienced with the Billiton operation, the following advantages have been identified in favour of a fully integrated APT processing plant:

a. The chemical dissolution of concentrates in caustic solution (APT hydromet) and crystallization of APT may be technically more viable than chemical methods to clean concentrates. The concentrates produced from Mt. Pleasant ores will always be considered "dirty" because of the intergrowth of mineral species. Chemical processing methods to clean concentrates are considered costly where APT chemical production processing methods have an add-on value to production.

b. Previous bench-scale studies have indicated that the major loss of wolframite in gravity separation is due to loss of fines (-25um). In order to improve on recovery of tungsten it has been recognized that a three-stage grind may be required to reduce fine content based on the liberation data and the wide range of wolframite grain size. If the APT circuit is capable of treating concentrates at 20% WO_3 (question of scale to favour economics), then the total liberation of wolframite is not required and energy requirements for grinding may be reduced.

c. The phasing out of tariffs, via free trade with the U.S.A., will result in new market opportunities for APT. The Free Trade Agreement with the U.S.A. will phase out a 10% tariff by 1993 and it is anticipated that this will create a favourable and competitive environment for Mt. Pleasant.

A limitation to commercial opportunities in tungsten ores and tungsten chemicals is the fall in commodity prices as illustrated in Figure 3. The depressed tungsten prices for concentrate reflects the closure of the Mount Pleasant operation, where most mining-milling operations have a breakeven on profitability* of $110(U.S.)/MTU WO_3 for concentrate sales. As indicated from Figure 4, the value of the ore, based on $110/MTU, is around $40(CDN)/tonne ore. Correlating the relationship between APT and concentrate prices as trended in Figure 3 (in the time frame 1978-1983), an add-on value or breakeven production cost for APT hydromet has been determined to be in the range of $13-16(U.S.)/tonne ore ($17.55-21.60(CDN)/tonne ore). In other words, the production cost of APT hydromet should be below this breakeven range in order to economically favour the sale of APT over concentrate. As a result, the total operating cost of the mine operation could realistically be represented as:

MINE OPERATION	COST/TONNE ORE	
Administration and Maintenance	2.50	
Mining and Underground Development	15.00	
Gravity Separation and Milling	8.00	
APT Hydromet	21.60	
TOTAL MINE OPERATING COST	47.10	
Approximate Value of Mine Ore (based on APT Sales)	52.00	(1982)

*Reported in Roskill Economics for Mt. Pleasant and various Korean operations.

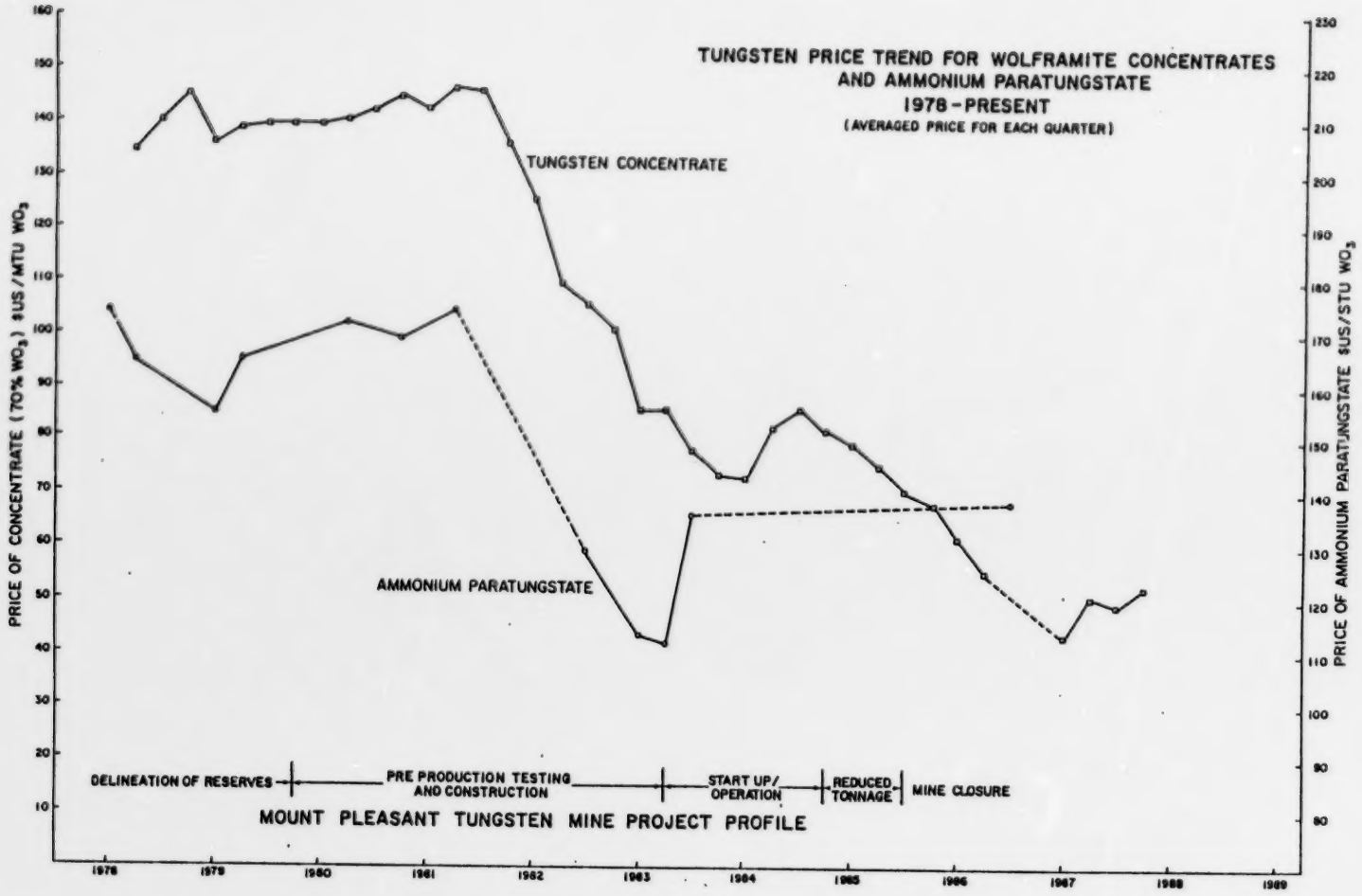
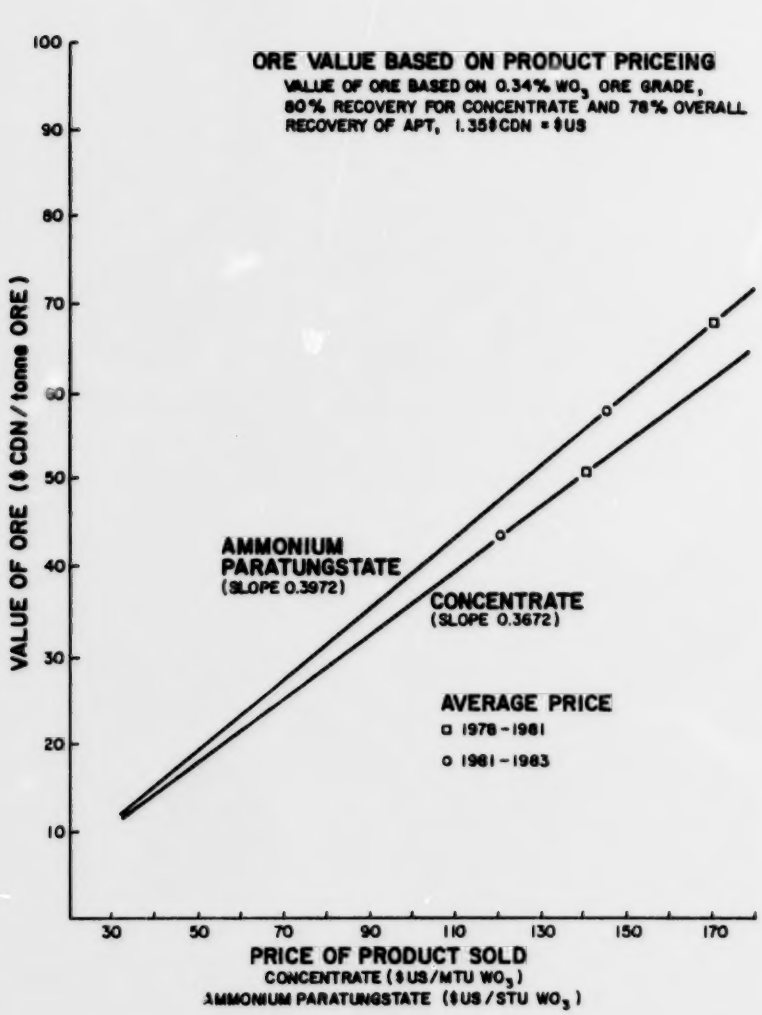


FIGURE 3: Price trends for tungsten concentrates and ammonium paratungstage.


ORE VALUE BASED ON PRODUCT PRICEING
VALUE OF ORE BASED ON 0.34% WO_3 ORE GRADE, 80% RECOVERY FOR CONCENTRATE AND 78% OVERALL RECOVERY OF APT, 1.35$CDN = $US
VALUE OF ORE ($CDN / tonne ORE)
AMMONIUM PARATUNGSTATE (SLOPE 0.3972)
CONCENTRATE (SLOPE 0.3672)
AVERAGE PRICE
□ 1978 - 1981
○ 1981 - 1983
PRICE OF PRODUCT SOLD
CONCENTRATE ($US/MTU WO_3)
AMMONIUM PARATUNGSTATE ($US/STU WO_3)

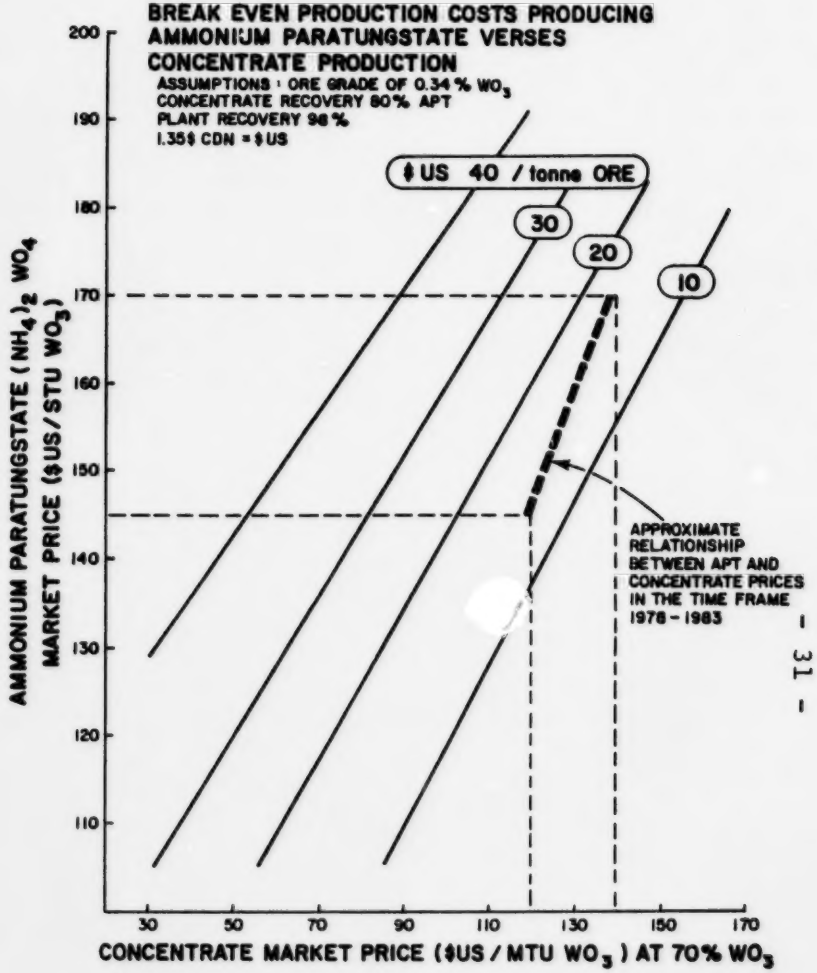

BREAK EVEN PRODUCTION COSTS PRODUCING AMMONIUM PARATUNGSTATE VERSES CONCENTRATE PRODUCTION
ASSUMPTIONS : ORE GRADE OF 0.34 % WO_3
CONCENTRATE RECOVERY 80% APT
PLANT RECOVERY 98 %
1.35$ CDN = $US
$US 40 / tonne ORE
30
20
10
APPROXIMATE RELATIONSHIP BETWEEN APT AND CONCENTRATE PRICES IN THE TIME FRAME 1978 - 1983
AMMONIUM PARATUNGSTATE $(NH_4)_2 WO_4$ MARKET PRICE ($US/STU WO_3)
CONCENTRATE MARKET PRICE ($US / MTU WO_3) AT 70% WO_3

FIGURE 4: Value of ore and the relationship between revenue from concentrate and add-on value of ammonium paratungstate production.

The closure of the Mount Pleasant operation, at a time of suppressed metal prices, has prompted an era of development, where concepts have been reviewed to establish a competitive edge for the deposit in anticipation of increasing metal prices. The concept of producing APT has been recognized as the most probable commercial technology for Mount Pleasant tungsten. Work carried out to date on producing APT from flotation concentrates has indicated development limitations, recognizing the fact that the elemental makeup of gravity concentrates will be different than flotation concentrates particularly with lead contents. As a result of our studies, the technology for selective leaching and purification of sodium tungstate solutions will have to be addressed to develop a competitive edge for this deposit. Costing of an APT hydromet for the production of 1,950 t/a APT is presently being carried out to establish a preliminary operating cost and identifying areas for economic improvements.

One should be aware of developing technologies that may replace the production of APT. This will include chlorination technology, which would eliminate APT production, where tungsten carbide can be produced directly from ores and concentrate. This technology has not been recognized as commercial technology because the powder size of tungsten carbide cannot be predictably controlled. However, future developments with Mount Pleasant Tungsten should include a review of chlorination technology research.

A major concern with the concept of producing APT at Mount Pleasant is the scale of production. Based on other APT plants as outlined in Table 5, the production tonnage of 1,950 t/a APT based on 2,000 t/d ore may be the maximum desirable operation. It is difficult to estimate or predict export tonnages of APT because of figures are published as tungsten compounds and not reported solely for APT. In 1984, the U.S.A. imported 1,000 t/a of APT from China, but this high import tonnage may be due to the underselling price of APT. However, the location in New Brunswick may in itself be a competitive edge for future markets possibly within NATO countries, compared to major North American APT production in California.

Benefication of Complex Sulfides

The concept of a custom mill, as indicated in Table 1, includes a fully integrated plant capable of treating the various complex sulfide ores and producing a high grade metal or a metal complex of favourable economics. To date, various flowsheet options for a custom mill have been identified, where further work is being carried out on flotation flowsheet selection to produce a bulk concentrate. As part of this project, flowsheet simulation via computer modelling, options on grinding and modelling of grinding circuits and use of column flotation techniques are all being reviewed to provide data for scale-up and economics on bulk sulfide flotation. It is anticipated that the work carried out on this project relating to computer simulation of flotation circuits, will lead to a better understanding of flowsheet design for complex sulfides and

provide an operating tool for the optimization of flotation flowsheets in mills. This information will provide a key link to a next generation of process control using "expert systems".

Mineral Investment Stimulation Program

A total of 16 projects have been approved for financial assistance under the MISP and are distributed among five different companies; including both developers and operators. Collectively, these projects have been focusing development activity on three main areas; process optimization, new product development and extension of reserves. The former two are process related and have entailed eight projects initiated by Durham Resources Inc. and Brunswick Mining and Smelting. Six projects were directed at process optimization with a project split of 4 to 2, respectively. The remaining two dealt with the technical assessment of producing antimony metal at Durham and a pyrite concentrate at BM&S.

The latter observed development area is of geological nature and has been dealing mostly with the further characterization or extension of deposits classified as "established mineral deposits". Eight projects of this nature have been approved among four companies; Durham Resources, Mispec Resources, Maritime Research Ltd., and Lacana Mining Corp. Except for Durham, these companies represent the nonoperating, grass-roots developers within the Province.

As the MISP is an industry-driven assistance program, the projects initiated, within the guidelines of the program would seemingly be in line with the development priorities of industry. To date, there is considerable activity in resource definition and plant optimization but very little activity in process and market development of new deposits. In view of mineral resource development, nonoperating companies (developers) are in the very early stages in that they are proving the potential of their resources as a prerequisite to further development in the processing sector. Discussions have indicated that further downstream development may be warranted depending on the availability of incentives (via the MISP).

Conclusions

The mandate for projects administered by the Process Studies Group is to identify "commercial development concepts" and to assist the mining industry of New Brunswick with development projects. The following conclusions reflect the projects presently active and does not reflect the total findings of development programs administered to date nor does this discussion include development by the private sector.

* The major areas that contribute to development of the mining sector in New Brunswick as experienced with administering the Mineral Processing Investigation Program (MPIP) and Mineral Investment Stimulation Program (MISP), have been acknowledged to include the delineation of resources (quantification of resource tonnage and grade), identifying marketing opportunities, and applied research in commercial process technology.

* Various development concepts have been identified under the MPIP, known as commercial business opportunities, however, further development work will be required. The purpose of MPIP is to evaluate these opportunities by carrying out preliminary technical and economic feasibilities and identifying limitations.

* Opportunities in specialty metals have been recognized as an area for diversification of the mining industry into future high growth metal, where some of these metals are high value-low tonnage commodities. Further development is required on resource delineation and reviewing the potential of stand-alone operations, having ores and/or concentrates imported to New Brunswick for refining.

* The concept of producing ammonium paratungstate (APT) at Mount Pleasant has been recognized as the most probable development opportunity for tungsten based on the technical separation difficulties with the ore. Further development on a gravity-APT flowsheet will required.

Financial Report

The cost of administering both programs and project expenditures per annum, is outlined in the following financial report. A total of $110,000/annually of federal monies under the Mineral Development Agreement is used for administration of both programs. Multiyear cashflow for development programs is shown in Table 6.

TABLE 6: Development Programs Multiyear Cashflow (Federal Funding)

Revision: Dec. 31, 1987

ITEM	FY 86/87	FY 87/88	FY 88/89	FY 89/90	TOTAL BUDGET
Mineral Process Investigation Program					
Administration (Person Years)	121,000(2)	60,000(2)	70,000(2.5)	8,000(5)	259,000(7)
Projects	79,000	50,000	10,000	2,000	141,000
	200,000	110,000	80,000	10,000	400,000
Mineral Investment Stimulation Program					
Administration (Person Years)	32,799(0.5)	50,000(1)	60,000(1.5)	50,000(1.5)	192,799(4.5)
Projects	58,445	383,000	295,756	70,000	807,201
	91,244	433,000	355,756	120,000	1,000,000(11.5)

NOTE: FY 88/87 are actual expenditures

MINERAL PROCESSING INVESTIGATION PROGRAM (Federal Monies)

FINANCIAL REPORT (Third Quarter 87-88)

	Budget March 31/88	Committed Dec. 31/87	Balance To Dec 31/87
Program Administration	$ 60,000	$ 41,596.71	$18,403.29
Benef. of Complex Sulfides	10,000	7,668.87	2,331.13
Process Dev. Of Mt. Pleasant	15,000	15,645.88	(645.88)
Processing of Sp. Metals	25,000*	25,014.39	(14.39)
Cash Position	110,000	89,925.85	20,074.15

*REVISED FROM 15,000

MINERAL INVESTMENT STIMULATION PROGRAM (Federal Monies)

FINANCIAL REPORT (Third Quarter 87-88) .

	Budget	Program Budget To March 31/88	Committed Dec. 31/87	Balance To Dec. 31/87
Program ADM. (Year 2)	50,000		34,944	15,056
BMS-metal dist.	21,000		0	21,000
BMS-Pyrite float	11,795		0	11,795
BMS-Press. Filter	14,507		0	14,507
Durham-flash float	11,620		11,620	0
BMS-column float	10,200		10,200	0
Maritime R.R.-Woodstock Mn.	50,000		30,000	20,000
MISPEC-Cape Spencer Au	50,000		50,000	0
Durham Gold-Lake George	50,000		30,000	20,000
Durham Antimony veins-Lake George (1)	50,000		30,000	20,000
Durham Antimony veins-Lake George (2)	50,000		50,000	0
Gypsum-Eastern Gypsum	30,000		15,000	15,000
Cash Position	399,122	433,000	261,764	137,358